Indian J. Phys. **43**, 104–107, (1969)

Recording Instrument for measurement of thermal expansion

P. D. PATHAK, M. C. GUPTA AND J. M. TRIVEDI

Physics Dept., University School of Sciences,

Gujarat University, Ahmedabad.

(Received 30, *July* 1968 ; *Resubmitted* 27, *December* 1968 *)*

A recording instrument for the measurement of thermal expansion of solids is described in this article. The expansion of the specimen pushes mercury in a capillary tube in which a thin nichrome wire is placed. The potential difference across the wire changes when mercury moves in the tube. The changes in the potential difference are fed to a chart recorder. The sensitivity of the instrument can be varied within wide limits by employing capillary tubes of different bores or by changing the inclination of the tube to the horizontal. With suitable modifications, the instrument can be used for liquids and gases.

INTRODUCTION

Considerable attention has recently been devoted to the measurment of thermal expansion of solids not only from the point of view of obtaining accurate and reliable data on different solids but as a means of studying other properties of farreaching importance. For example, the measurement of thermal expansion can given useful information about the lattice vibrations in crystals, the energy of formation and role of lattice defects in thermal properties, the mechanism of phase transition, the release or absorption of energy in transitions of ferromagnetic materials etc.

Various optical, electrical, mechanical and other devices are employed in order to measure small changes in length. For large speciments, simple optical lever may give good results while for small specimens interferometric methods are more common. Various other ingenious devices are also employed (Shapiro *et al* 1964, Cook 1964, Bottom 1964).

On examining the literature we hardly come across methods in which the expansion of a solid on heating can be transferred to a chart and hence obtain a permanent record which would be available at any time for the study of the internal processes occurring in solids.

In this paper, a simple instrument is described which can be built up from materials available in any common laboratory, so that a permanent record showing the relation between temperature and expansion of a solid can be obtained.

With the present instrument the thermal expansion of 99.99% pure aluminium is measured from room temperature to about 400°C to illustrate the accuracy of the instrument. The thermal expansion of 99.99% pure nickel is also measured from room temperature to about 500°C to to show how the study of phase changes can be undertaken with the help of the instrument.

The instrument

The present instrument is shown schematically in figure 1. It consists of a fused silica tube T of about 22 cm. in length and 0.8 cm. in diameter. It is surrounded by nichrome heating coil HH. It is placed horizontally in a wooden box A which is then filled with magnesia powder. P_1 and P_2 are fused silica rods. The length of P_1 is such that the specimen rod S, whose expansion is to be measured, remains in the centre of the tube T.

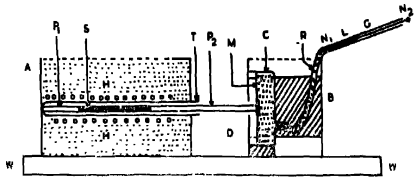

Figure 1

The other box B contains a small metal box C whose front surface M consists of a thin rubber membrane. A small thin circular metal piece was fixed at the centre of the membrane. The rod $P2$ is in contact with this rubber membrane and when it expands it pushes the membrane inward.

The box C contains pure mercury and is connected to a glass capillary G, of about 50 cm. length, by a rubber tube R. When the specimen S expands the rod $P2$ pushes the rubber membrane M inward and the mercury level L in the capillary moves forward. A millimeter scale placed behind the capillary tube enables the movement of the mercury level to be measured.

A thin nichrome wire $N_1 N_2$ of about 12 ohms resistance is placed inside the capillary tube so that a part of it remains within the mercury column. The points N_1 N_2 (*i. e.* C and N_2) are joined in series to a

battery and a resistance so that a potential difference of about 20 mV is obtained across the wire. The movement of the mercury level L, as the specimen expands, increases or decreases the potential difference. The points N_1 N_2 are also connected to a chart recorder.

The box A is fixed to a rigid wooden plank WW. The box B can slide on WW and can be fixed at any desired position. It is moved to a position in which the push rod $P2$ touches the front rubber membrane M. It is then pushed a little forward so that the mercury level L moves by about 0.5 cm. This ensures that the push rod is firmly in contact with the membrane. The box B is then fixed firmly on WW by clamping screws.

One of the great advantages of this instrument is that its sensitivity can be altered by (i) employing capillary tubes of different bores and (ii) changing the inclination of the glass tube G to the horizontal. Thus specimens with low as well as high thermal expansion can be investigated by the same instrument. With a specimen of about 10 cm. in length an accuracy of about $\pm \frac{1}{2}$ % can be easily obtained. With suitable modifications, the instrument can be used for measuring the expansion of liquids and gases. Since the viscosity of mercury is a factor to be considered, the temperature of the specimen should be increased very slowly especially when studying the phase changes *e. g.* ferromagnetic transition in nickel or iron.

The observations were taken on aluminium and nickel rods of 10 cm. length and 0.5 cm. diameter. The purity of aluminium and nickel was 99.99% and were obtained from Messrs Johnson Mathey and Co. Ltd., London. The results on aluminium agreed very well with those of other workers.

Since the results obtained by different workers on the thermal expansion of nickel vary widely (Owen & Yates 1936, Nix & MacNair 1941, Mikryukov and Kamilov 1962), the results obtained in the present investigation are of importance. They are presented in the following table. The temperature of transition was found to be 357°C.

Temp. °C	$\alpha \times 10^6$	Temp. °C	$\alpha \times 10^6$
0	12.5	350	22.6
100	13.7	357	23.5
200	14.9		
250	15.5	400	16.1
300	17.4	450	17.0
320	19.1	500	17.6

References

Bottom, V. E. 1964 *Rev. Sci. Instrum.*, **35**, 374.

Cook, L. M. 1964 *Rev. Sci. Instrum.*, **35**, 758.

Mikryukov, V. E. & Kamilov, I. K. 1962 *Instrum. Exper Tech.* (U. S. A.), **3**, 581.

Nix, F. F. & MacNair, D. 1941 *Phys. Rev.*, **60**, 597.

Owen, E. A. & Yates, 1936 *Phil. Mag.*, **21**, 809.

Shapiro, J. M. Taylor, D. R. & Graham, G. M. 1964 *Canad. J. Phys.*, **42**, 835.